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REPORT OF THE IOFC WORKING PARTY ON STOCK ASSESSMENT IN RELATION TO IMMEDIATE PROBLEMS OF MANAGEMENT IN THE INDIAN OCEAN

Rome, 30 September - 3 October 1969

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1969

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, December 1969

PREPARATION OF THIS REPORT

At its first meeting in Rome, 16-20 September 1968, the Indian Ocean Fishery Commission decided to establish two committees (a Committee on the Management of Indian Ocean Tuna, and a Committee on the Management of Gulf Shrimp) to consider the steps required to introduce management measures when these are necessary. These Committees should be advised by a small working party of experts in the field of stock assessment.

This working party met in Rome in September 1969, and the present document is its report, as approved by correspondence between the members.

Statements in this report do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

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1. INTRODUCTION

At the request of the FAO Committee on Fisheries, a group of experts was convened by the IPFC to examine the status of fisheries and assessment of potential resources of the Indian Ocean and adjacent seas. The findings of this group are reported in FR/R54. Subsequently a group of experts on tuna stock assessment was convened, under the FAO Expert Panel for the Facilitation of Tuna Research, to examine the then present status of the tuna stocks in the Atlantic and Indian Ocean, FRs/R61 (Miami report). It was the conclusion of this latter group that the longline fishery for tunas in the Indian Ocean was producing tuna at the maximum level which the stocks could support, with the exception perhaps of bigeye, and any further increase in effort would probably not result in increased production.

The Committee on Fisheries also requested that such information as could be made available by the countries concerned should be assembled on the fisheries in the Gulf between Iran and the Arabian peninsula, and a report summarizing this information was presented at the first session of the Indian Ocean Fisheries Commission (IOFC/68/Inf.11).

At the request of the IOFC, based on the findings of the reports noted above, a group was established to examine information on the present condition of the stocks of tuna in the Indian Ocean and shrimp in the gulf between Iran and the Arabian peninsula, and to report their findings to committees of nations on shrimp and tuna established by the IOFC, along with the assessments of the condition of these stocks and recommendations, if necessary, for alternative approaches to the rational management of these resources.

A meeting of this group was held at FAO Headquarters in Rome, from 30 September to 3 October 1969. The members of the group were:

B.K. Bowen - Director, Department of Fisheries and Fauna, Government of Western Australia, 108 Adelaide Street, Perth, Australia

J. Joseph - Director of Investigations, Inter-American Tropical Tuna Commission, c/o Scripps Institution of Oceanography, La Jolla, California, USA

A. Suda - Far Seas Fisheries Research Laboratory, 1000, Orido, Shimizu 424, Japan

A. White, Fisheries Adviser, Trucial States Council, Fisheries Department, P.O. Box 2539, Dubai, Arabian Gulf, was unable to attend the meeting, but was consulted by correspondence. The meeting was also attended by J.A. Gulland and L.K. Boerema, Fish Stock Evaluation Branch, FAO.

2. TUNA

2.1 The longline fisheries

2.1.1 The state of the stocks

Data on the condition of the stocks of tunas in the Indian Ocean have been presented previously in the Report of the IPFC Group of Experts on the Indian Ocean (FR/R54) and the Report of the Meeting of a Group of Experts on Tuna Stock Assessment (FRs/R61). The former report considered catch-statistical data during the period 1952-64 and the latter report extended these data through 1966. In the present report we include data for 1967. Whereas the earlier two reports considered only information in the Japanese longline fishery, we have included information on the Korean and Formosan fisheries as well.

Prior to 1963, nearly all of the tuna captured from the Indian Ocean were taken by the longline fishing fleet of Japan. In Figure 1 we show the total catch, by species, taken by the Japanese longline fishery from the Indian Ocean. Since 1963, Korea and Formosa have entered in a substantial way into the longline fishery in the Indian Ocean. In Figure 2 catches of tuna by species for the fleets of Japan, Korea, and Formosa fishing in the Indian Ocean are shown for the period 1963-67.

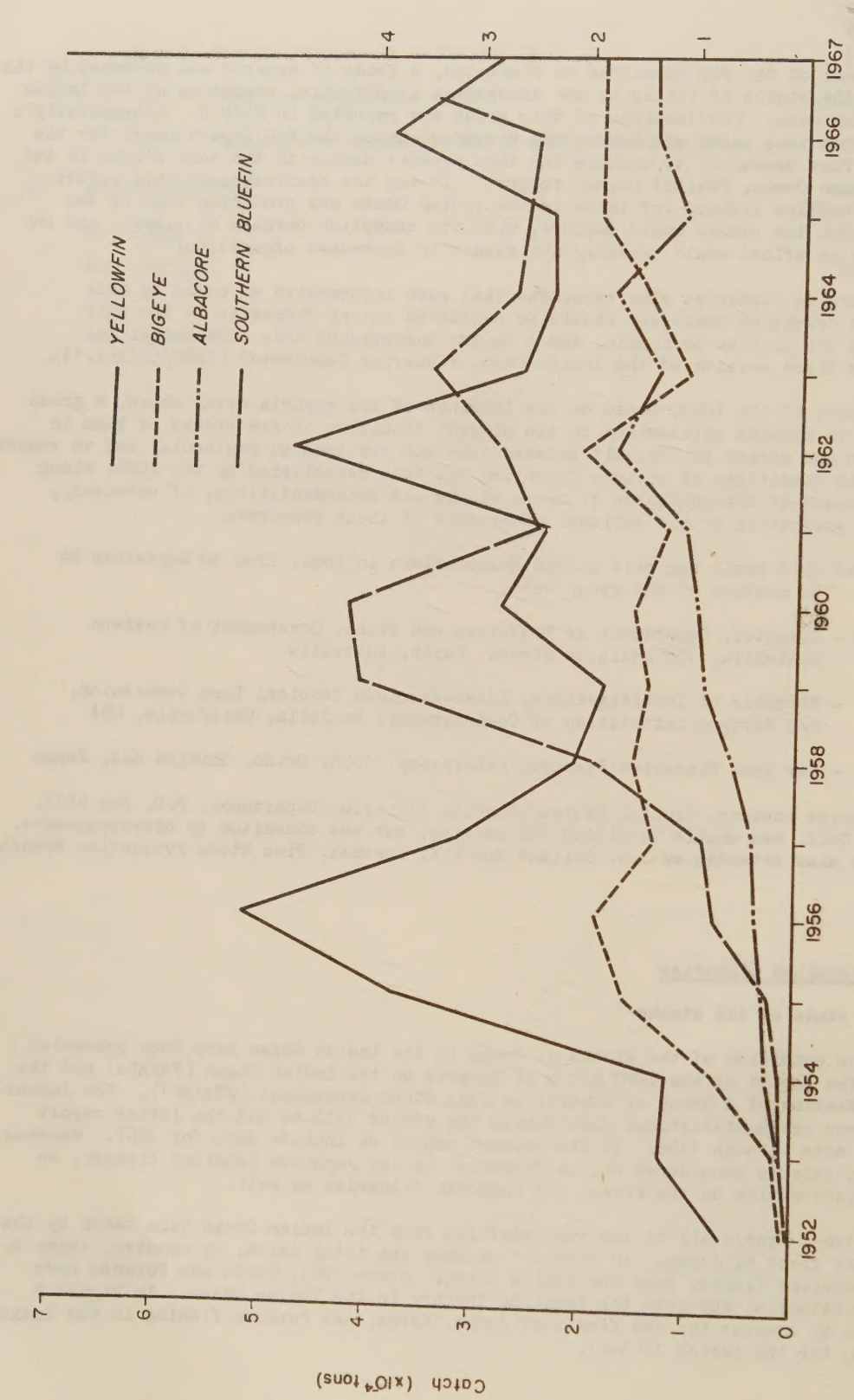

Figure 1. Estimated total tuna catch by Japanese longliners in the Indian Ocean, 1952-67 (from Kikawa et al.)

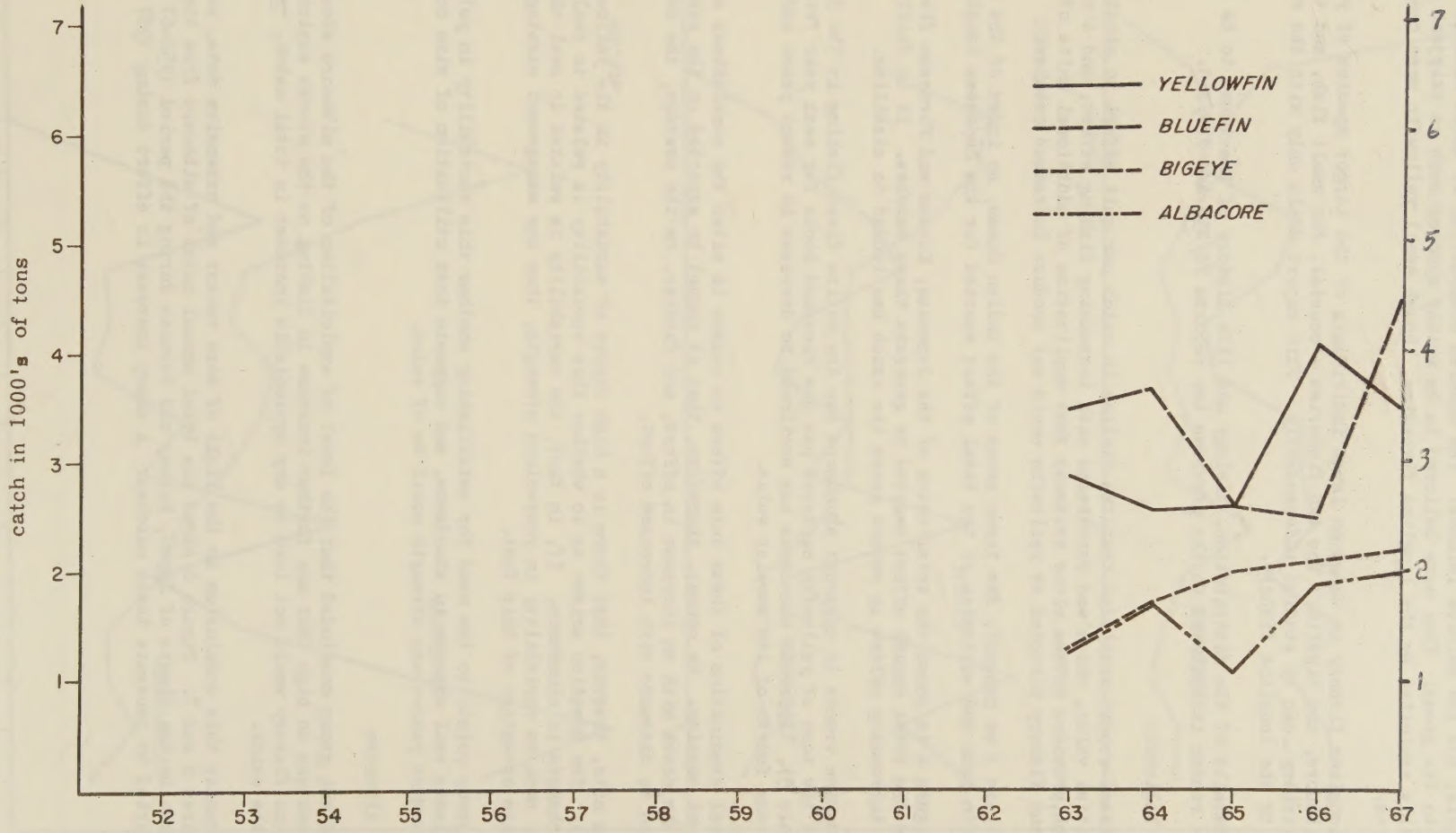

Figure 2. Total catch for Japan, Korea and Formosa of longline caught of yellowfin, bluefin, bigeye and albacore during the period 1952-67. Catch prior to 1963 for Japan only.

Published statistics also show that quantities of tuna or tuna-like fishes are taken by Ceylon, India, and the Maldive Islands. The species composition of these catches were not available to the group. They were believed to be mainly species such as skipjack which are not generally exploited by the longline fisheries, though small yellowfin were caught around the Maldives.

The longline fishery is based on large individuals of the larger species of yellowfin, bigeye, albacore, and bluefin. The two fisheries - coastal, for small fish, and the oceanic, longline fishery - can be studied independently. This report deals only with the stocks exploited by the longline fishery.

For details of the distribution, biology and life history of the tunas to be discussed below, the reader is referred to the previous two reports FR/R54 and FRs/R61.

(a) Yellowfin

The Miami report concluded that the decline in catch per unit effort to about a quarter of its initial value, which was correlated with increasing fishing effort, and a non-increasing total catch, provided rather clear evidence that application of additional units of effort in the longline fishery directed at yellowfin would not produce increased catches.

In Figure 3 we present, for three areas of the Indian Ocean, an index of the abundance of yellowfin tuna and estimates of the total effort exerted for the Japanese longline fishery.

In Figure 4 is shown the total catch of the Japanese, Korean and Formosan fleets in weight and the total annual effort exerted to generate these catches. It is fairly obvious that with increasing effort in recent years the catch has tended to stabilize.

To examine trends in apparent abundance for the entire fleet fishing in the Indian Ocean, we present the tons of yellowfin captured per one thousand hooks for each year from 1954 to 1967 (Figure 5). Apparent abundance has continued to decrease in recent years and in 1967 was about one fourth of its earlier value.

General examination of these data offers no reason to alter the conclusions arrived at by the Miami meeting. We concur, therefore, that it cannot be expected on the average to increase the catch with an increase in effort, and further, on the average, the catch might be expected to decrease with increased effort.

We do note, however, that there is a high degree of variability in the yellowfin catch (Figure 4). The question arises as to whether this variability is related to real or apparent changes in abundance. If, in fact, the variability is related to real changes in abundance, such as variability in year-class strength, then any management strategy would want to take advantage of this fact.

The group points to the need for establishing whether this variability in yellowfin catch reflects real changes in abundance, and suggests that utilisation of size composition data to examine year-class strength would be of value.

(b) Albacore

The Miami group concluded that the level of exploitation of the albacore stocks in the Indian Ocean was so high that any further increase in fishing on the stocks exploited by the longline fishery would not lead to any appreciable increase in total catch, and could decrease the catch.

To examine this conclusion in the light of more recent and extensive data, we have prepared Figures 6 and 7. Figure 6 shows the total annual catch of albacore from the Indian Ocean, taken by the fleets of Japan, Korea, and Formosa during the period 1952-67 and the effort exerted to generate these catches. A sharp increase in effort during 1967 was

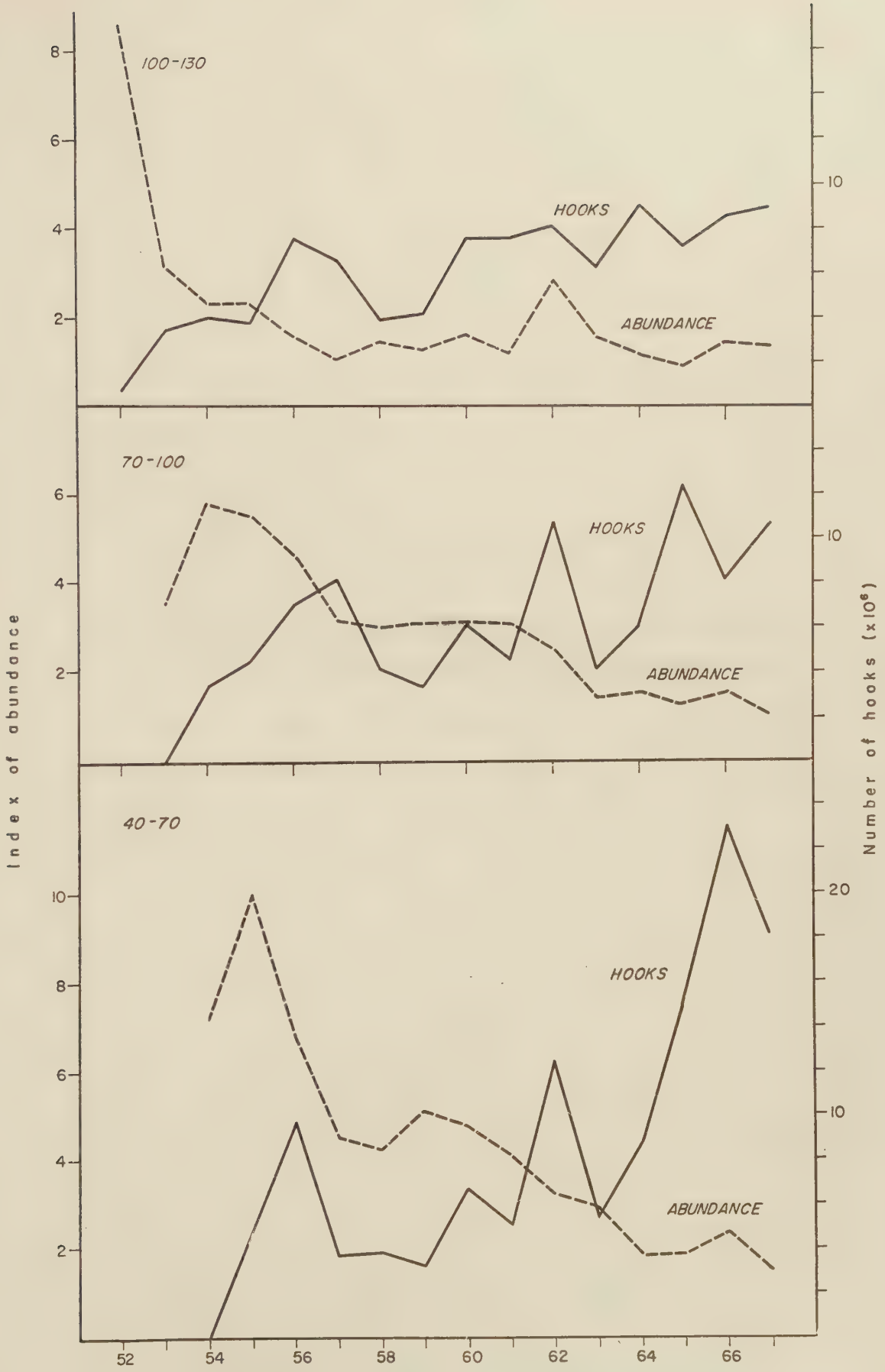

Figure 3. Annual changes in relative abundance of yellowfin tuna and fishing effort, 1952-67 (from Kikawa et al.)

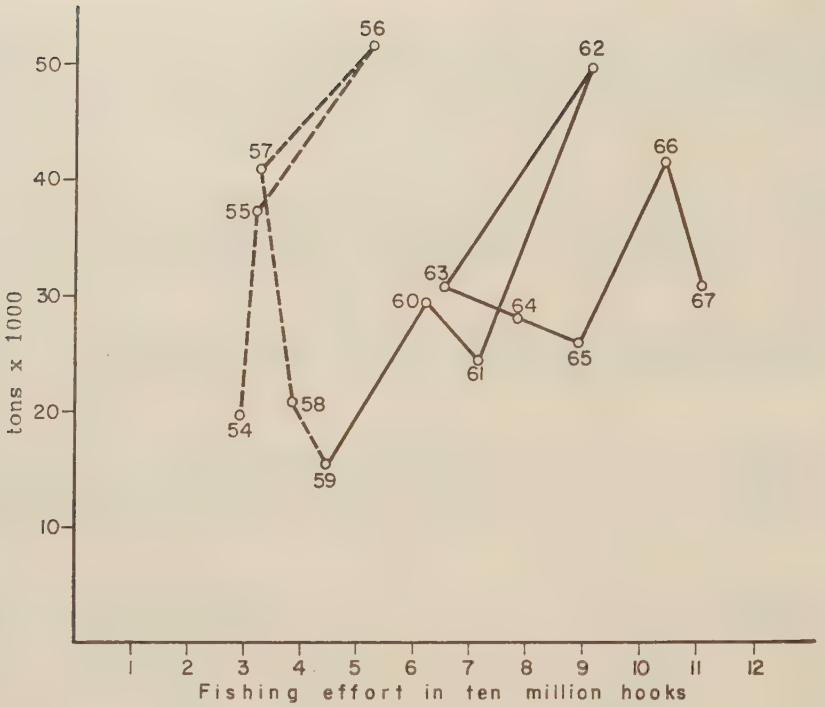

Figure 4. Total catch of yellowfin and total effort in millions of hooks for yellowfin tuna in the Indian Ocean by Japan, Korea and Formosa, 1954-67

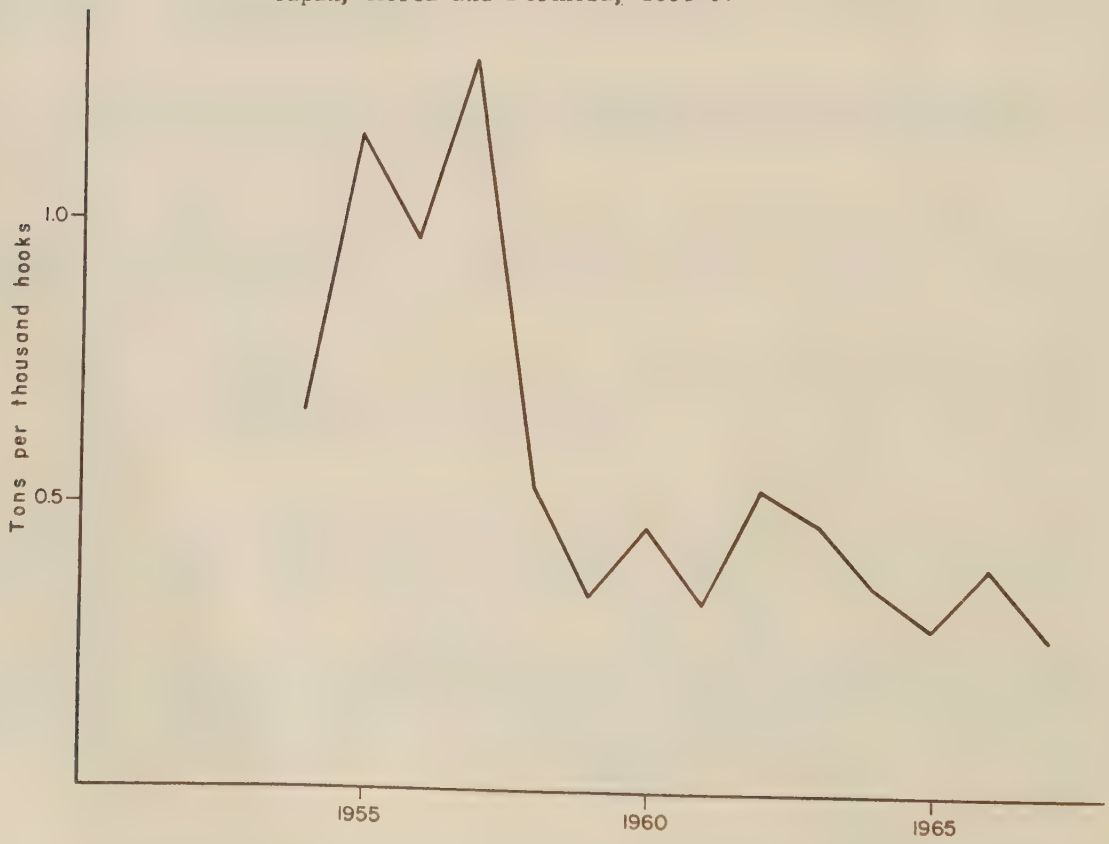

Figure 5. Catch of yellowfin in tons per 1000 hooks for the Japanese fishery in the Indian Ocean, 1954-67

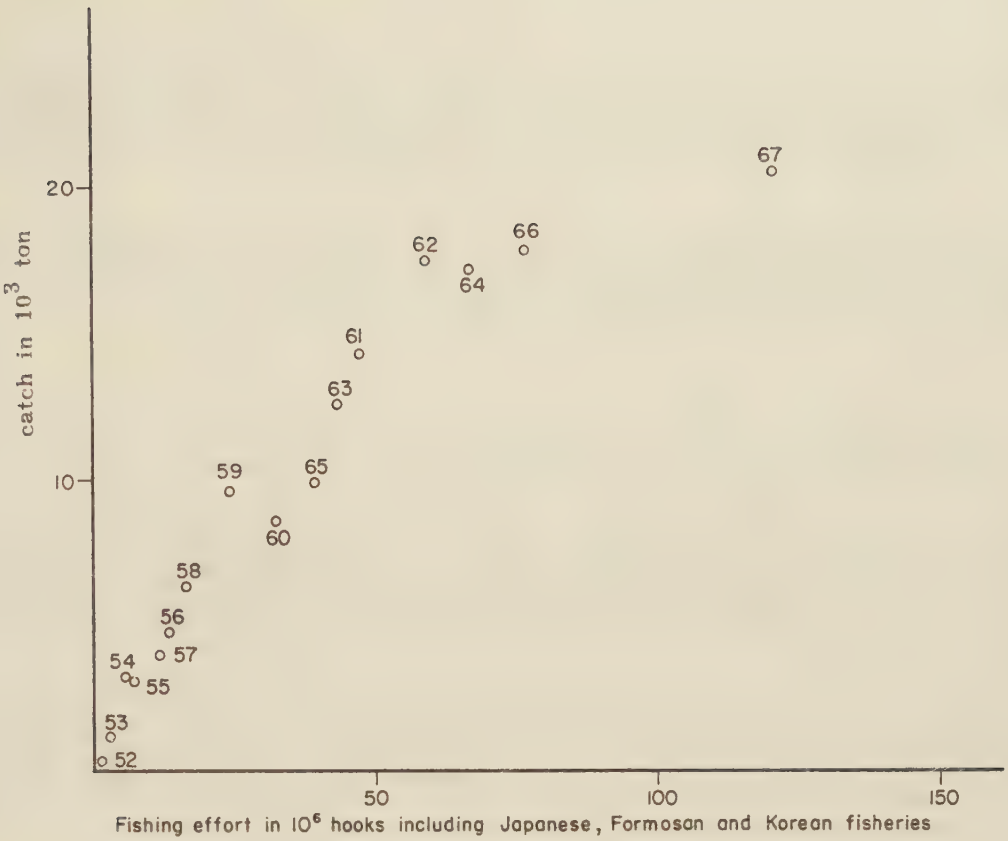

Figure 6. Catch and effort statistics of the Indian Ocean albacore

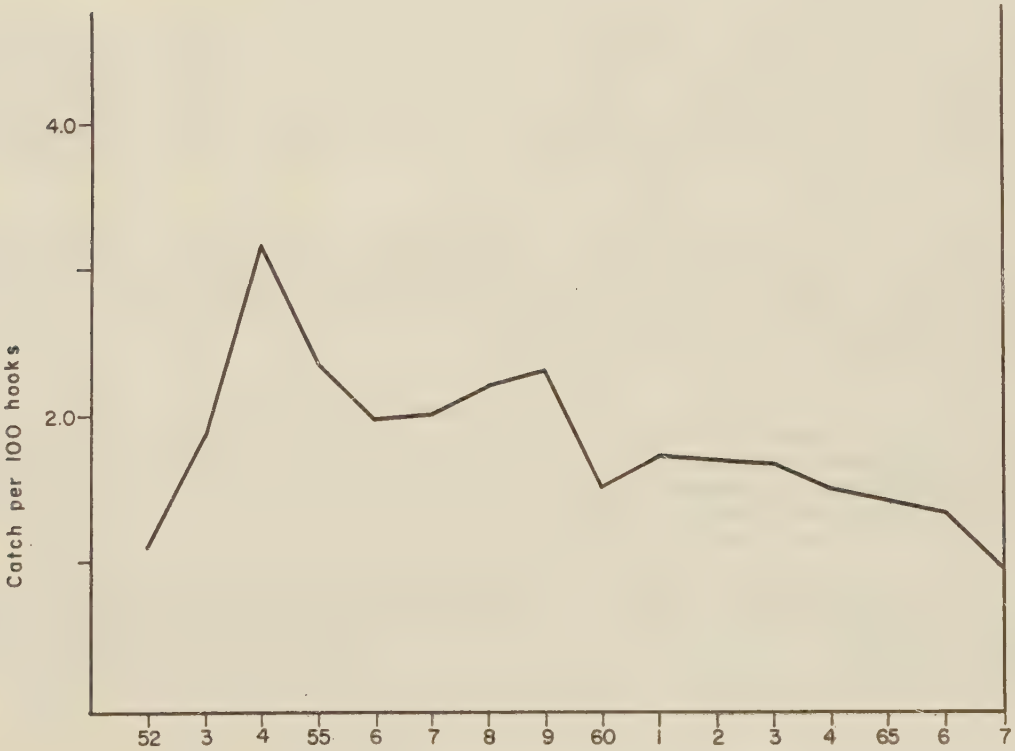

Figure 7. Catch in numbers of albacore per 100 hooks by Japanese vessels in the Indian Ocean, 1952-67 (from Kikawa et al.)

evident, but, however, as predicted by the Miami group, this resulted in only a slight increase in catch. The index of abundance, in terms of catch in numbers of albacore per 100 hooks, for the entire area of the Indian Ocean fished by the Japanese longline fleet, is shown in Figure 7. This figure shows a sharp decrease in the relative abundances of albacore during 1967.

On the basis of this examination of recent data, we concur with the findings of the Miami report. Though the effort in 1967 increased sharply, the catch increased only slightly. It is likely that this very slight increase in catch is only temporary and if effort continues at the 1967 level or higher the catch will not increase and may decrease.

(c) Bigeye

It was concluded in the Miami report that bigeye in the Indian Ocean were most likely not being over-exploited and that it was probable that at least a moderate increase in the longline fishing effort would result in an increase in the total catch.

During 1967, a substantial increase in effort was related to a moderate decrease in apparent abundance in the Japanese longline fishery for bigeye (Figure 8). The combination of these factors did not result in an increase in the Japanese catch of bigeye from the Indian Ocean in 1967. However, the combined catch of bigeye for the Japanese, Korean and Formosan fleets increased in 1967, as did the effort generated to make this increased catch.

It is noted here that the present level of abundance of bigeye in the Indian Ocean is greater than one-half of the maximum level observed in the fishery (Figure 8). If abundance in the early years is well determined, then it would appear that the stock of bigeye in the Indian Ocean can support larger catches on a sustained basis. Judging, however, from the slight increase in catch during 1967, which was associated with a rather large increase in effort (Figure 9), it appears that the present level of catch may not be very much below the maximum potential yield for bigeye in the Indian Ocean. Additional data need to be examined for this species in the Indian Ocean, before these facts can be firmly established.

(d) Southern bluefin

Since the report of the Miami group, the distribution of fishing effort on and catch of southern bluefin has changed. Whereas previously catch and effort were most concentrated in the Indian Ocean near Australia between 10°-30°S and west to about 90°E it is now expanded between 170°W in the South Pacific through the south Indian Ocean (south of 30°S) to 10°W in the Atlantic Ocean. Since the last report of the Miami group, evidence has been presented which strongly suggeststhat the population of bluefin tuna occurring in the southern hemisphere is a single stock (Rynd 1969 and Shingu M.S.).

The Miami report only examined catch and effort statistics for bluefin taken in the Indian Ocean. Because we consider southern bluefin to be a single stock, we have examined data from the entire fishery, extending through three oceans. Figure 10 shows the catch in numbers and weight, number of hooks (effort) and hook-rate (index of abundance) for the period 1959 through 1967. In Figure 11, the relationship between total catch in weight and the effort generated to make these catches is shown.

In Figure 10, it is obvious that the current level of abundance is between 1/3 and 1/4 of the highest years shown on the graph. In 1967, a substantial increase in effort was observed, effort increasing from about 120 x 10^6 hooks to about 180 x 10^6 hooks. Catch in weight during this period increased from about 30,000 to about 45,000 tons. Though the catch showed a significant increase with effort, it did not approach the earlier 1960-61 levels of catch which were made with less than half of the effort generated in 1967.

It should be noted that bluefin is a long-lived fish (as many as ten age classes are observed in the fishery) and, therefore, it would be expected that there would be a long lag period before the full effect of the increased effort and catch in 1967 could be observed in subsequent abundance and catch.

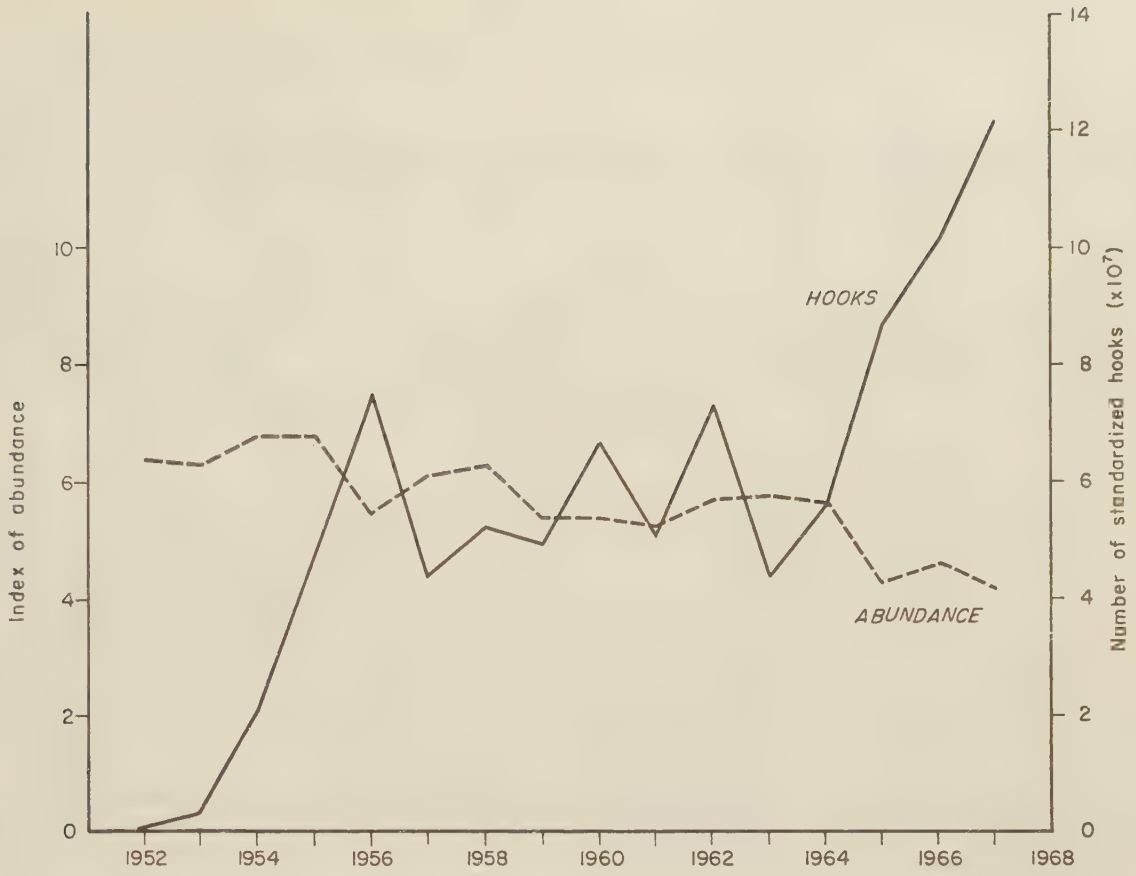

Figure 8. Annual changes in relative abundance of bigeye tuna (numbers of fish/1000 hook and fishing effort, 1952-67) in the Indian Ocean for the Japanese longline fishery (from Kikawa et al.)

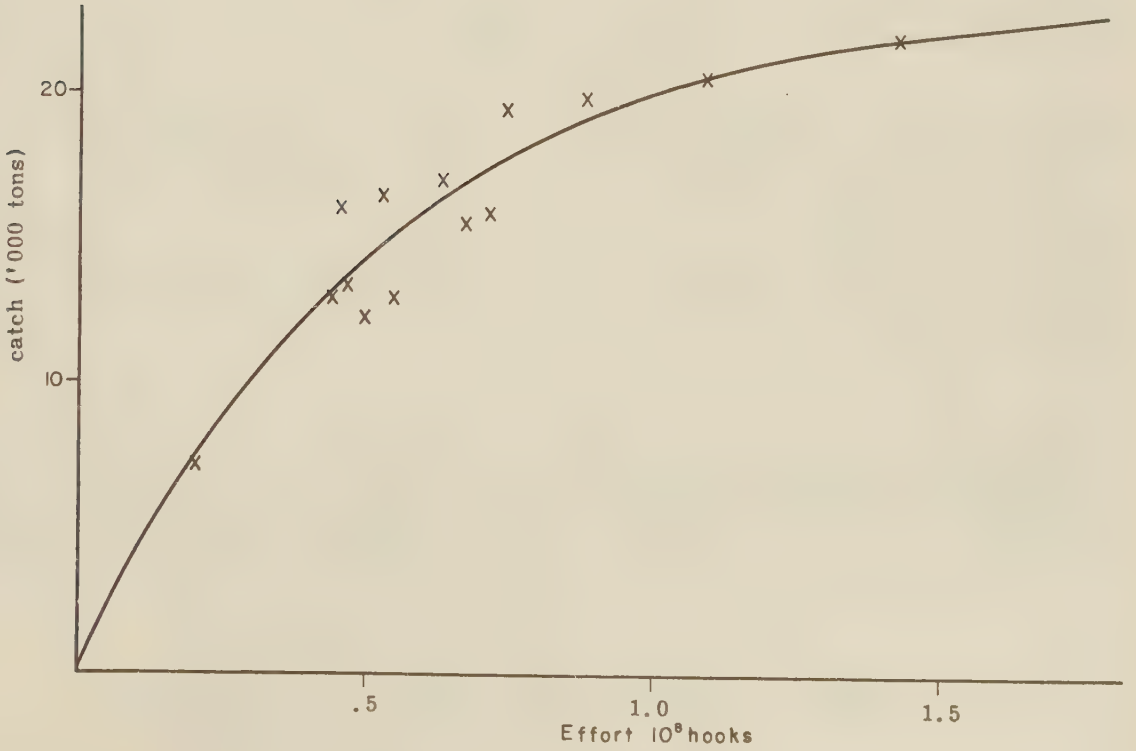

Figure 9. Total catch and effort for bigeye tuna for the Japanese, Korean and Formosan longline fishing in the Indian Ocean, 1954-67

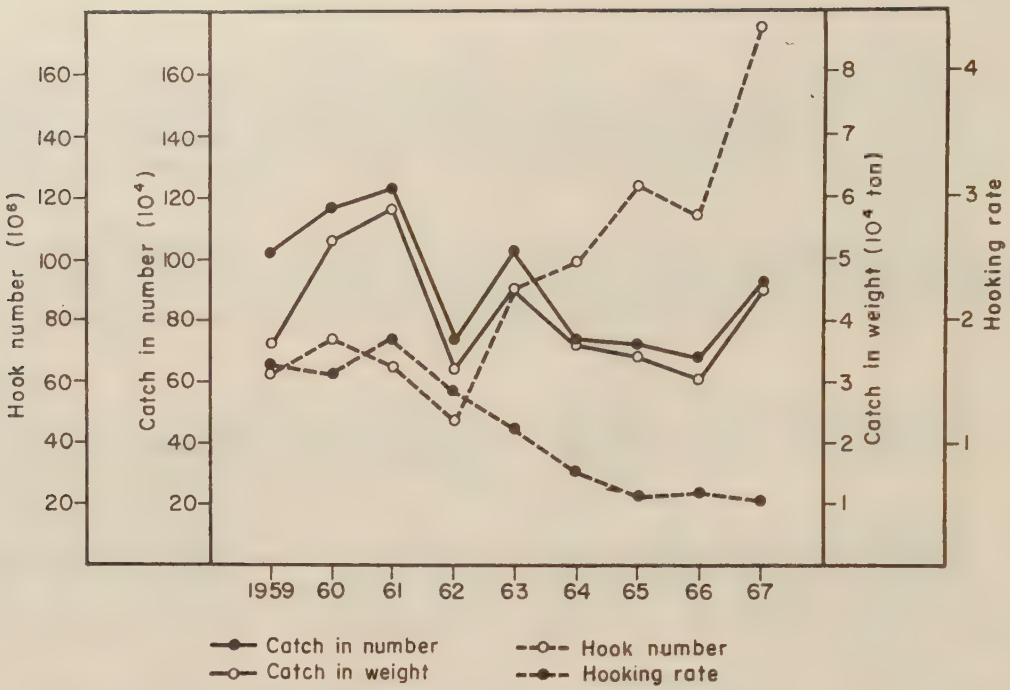

Figure 10. Annual changes of catch, number of hooks and hooking rate of southern bluefin by Japanese longliners from all areas of the Pacific, Indian and Atlantic Oceans, 1959-67

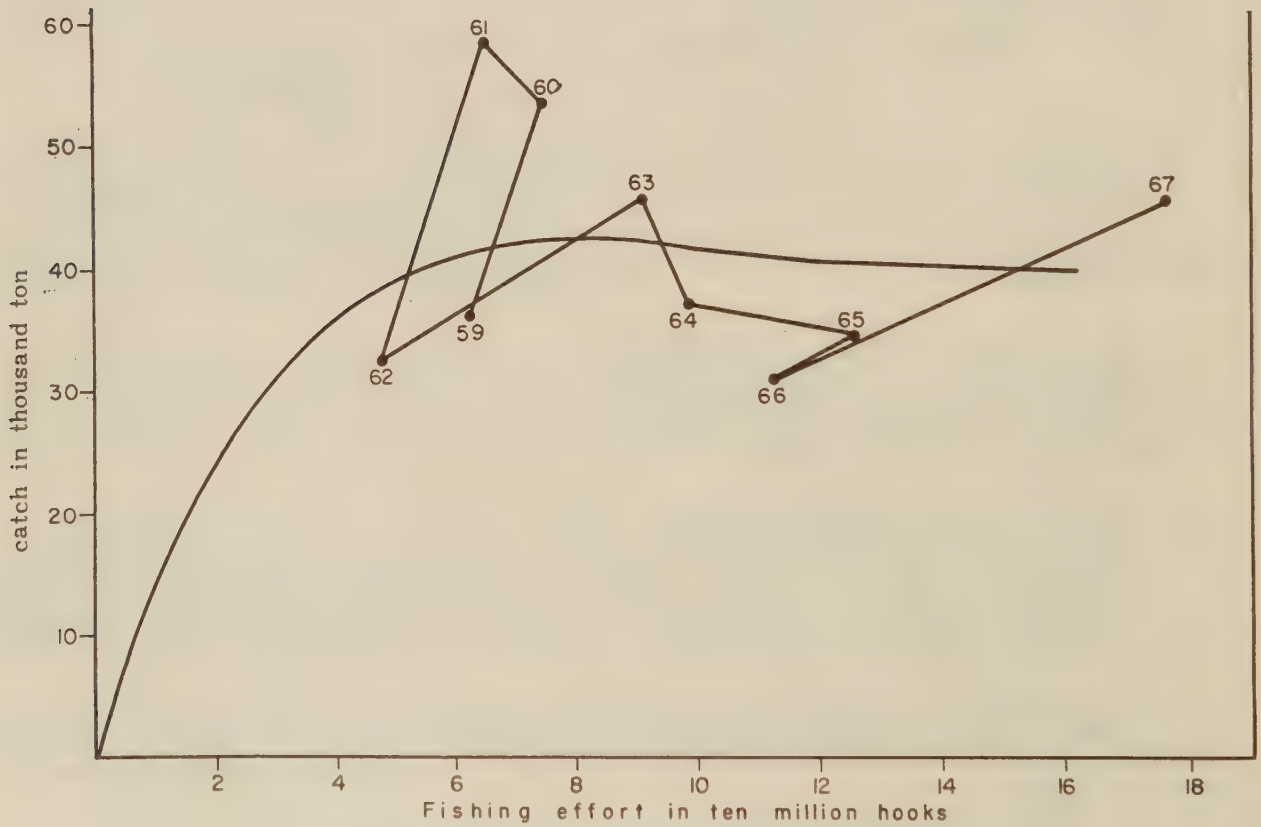

Figure 11. Relation between fishing effort and catch of southern bluefin, 1959-67, for all oceans

Therefore, caution should be exercised in increasing any fishing effort on this species. It is the opinion of the Working Party that the possibility exists that increased effort will not result in a sustained increase in catch, but likely in a decreased sustained catch.

2.1.2 Needs for management

On the basis of the data presented in FR/R54, FRs/R61 and in the paragraphs above, it is the opinion of the Working Party that if fishing effort in the Indian Ocean is expanded beyond the present level the total catch would most likely not increase. There is also the possibility that because the current level of fishing is reducing the adult spawning stock, recruitment to the fishable stocks and subsequent catch would be reduced. The group could not evaluate this possibility, but believe it is a real one.

The group wishes to emphasize the fact, as mentioned earlier, that bluefin is a long-lived species and the effects of over-exploitation on this species might not be readily observable in subsequent indices of abundance until after a considerable lag period after which the level of the stocks could have been reduced to a level much below the optimum level desired for rational exploitation of this species. Correspondingly there will be a considerable delay before any remedial measures take full effect.

We point out that under the most optimistic condition in the fishery, that is if the catch does not decrease with increasing effort, the catch of each individual vessel will on the average decrease as the total size of the fleet increases. Stated simply, with an increased capital investment, the total return in terms of tonnage caught will remain the same.

The group wishes to call attention to the international nature of the high seas longline fleets of the world. The vessels comprising these fleets are highly mobile and capable of fishing in all of the oceans of the world. This fact means that any management programme that might be established in the Indian Ocean will likely affect the longline fisheries in other oceans. For example (i) if the catch of tuna in the Indian Ocean is limited by a catch quota then after this quota is filled vessels fishing in the Indian Ocean will likely transfer their operations to other oceans where there is no restriction on catch, or (ii) if entry of vessels into the Indian Ocean fishery is limited to a certain number, then entrance of any new longline vessels into the tuna fisheries will necessarily have to take place in other oceans. Since the Miami report indicated that the state of the longline fisheries in the Atlantic and Pacific Oceans was similar to that in the Indian Ocean, a management programme in the Indian Ocean only would likely increase the problems in the Atlantic and Pacific Oceans. The group, therefore, points to the desirability of managing the stocks of tuna on a global scale.

The group concerned itself with the possibility of altering the total production of tuna taken by longline gear by altering the size at which they are captured. Because of a lack of data, it was not possible to determine the effect of size selectivity in the longline fishery. However, analyses suggest that for most species this strategy might make only a slight difference in total yield, because, with the exception of southern bluefin, it is not practicable to alter the size at first capture. In the case of bluefin, because they appear to show some differential distribution by size categories, it may be possible to alter the size at first capture for the longline fishery by avoiding the areas of the small fish. If this were possible, then it might be expected that total yield would increase somewhat.

2.1.3 Alternative approaches to management

Having discussed and reviewed the needs for management of the longline tuna fishery in the Indian Ocean, the group next concerned itself with possible approaches which could be taken to implement a management programme. Among the various approaches reviewed by the group curtailment of catch by establishment of catch quotas and by limiting the number of vessels in the fishery were discussed:

(a) Catch quotas

As discussed above, examination of pertinent data has suggested that a fixed quantity of each of the four species of tuna captured by longline vessels in the Indian Ocean can be taken on an annual basis. This amount was not determined by the group, but it would be a straightforward task to do so. For the convenience of the Commission, Table 1, which shows approximate estimates for values of maximum sustainable yield, has been included:

Table 1 - Sustainable yield of large tuna from the Indian Ocean

Species	Approximate average sustainable yield (in '000 of metric tons)
Yellowfin	30 - 35
Albacore	20 - 25
Bigeye	22 - 28
Southern bluefin	35 - 40

Before quota systems could be established, it would be necessary to determine more precisely the form of the sustainable yield curves for each species of tuna of concern, and the present position on these curves. Once these curves are determined, they can be used by the Commission to determine desirable levels for catch quotas. A number of different approaches to establishing a catch quota system could be taken.

One way in which this could be accomplished would be to establish a combined quota for all four species. Once this total amount of tuna was taken, additional catches would be disallowed. The major problem associated with an approach such as this, however, would be that the catch of an individual species could not be controlled and it would, therefore, be possible to drive a particular species to a very low level. This might be more likely for a species such as southern bluefin which commands a far higher price than the other species of tuna.

A second approach to the catch quota system is to set a quota on each species of tuna. When the particular species quota was filled, the further catch of that species would be disallowed. The major problem associated with such an approach is that the longline fishing gear is not selective to species, but rather catches whichever species is available. It is possible, and in fact quite common, for at least two and sometimes three of the four species of tuna to be taken on the same piece of longline gear at the same time.

A third approach, which leads directly from the problems associated with the first two would be to establish catch quotas within each species within sub-areas of the fishery in the Indian Ocean. With this approach, it would be theoretically possible to deploy the longline fleet into certain areas where a single species of tuna would be dominant in the catch. In such a situation, as the species quota was approached for a particular species, effort could be deployed from the areas of highest concentration of that species. Of course, to establish such a management programme detailed analysis of species composition in strata of time and area would need to be made.

The solution to a number of problems, in addition to those mentioned above, will have to be found before a system of management by catch quotas can be implemented. Obviously one of the most important will be a system for monitoring and the rapid reporting of catch data, from the high seas fleets, to the management agency, so that it can determine when to curtail fishing. Of equal importance is the establishment of a system for implementing, or enforcing, the possible management recommendations of the IOFC. Since the enforcement

authority of any management programme recommended by the Commission does not lie within the responsibility of the IOFC, it will be the responsibility of each nation to implement the recommendations of IOFC, and to enforce the necessary regulation to achieve the designated purposes of the management programme. It will, therefore, be necessary to establish a mechanism wherein these findings and recommendations can be reported to the nations involved in the exploitation of the tuna stocks of the Indian Ocean, but who are not members of the Commission. Since not all of the nations who capture tuna in the Indian Ocean are members of IOFC, it would not be possible at the present time for regulatory power to lie within the framework of IOFC as discussed in the report of the first session of the Indian Ocean Fishery Commission, FI/R60.

(b) Limited entry

An alternative to a single quota system based on catch is to limit the number of vessels that can participate in the fishery. Since the effort exerted by a tuna longline vessel is reasonably constant, a limitation of the number of vessels to the present (i.e. 1967) number would in principle maintain the effort, and catch at the present level, and any desired change in effort (fishing mortality) could be achieved by a proportional change in the permitted number of boats.

Some general problems of a scientific nature need resolution. First, it is necessary to devise and examine the curve of total catch against total effort to determine what level of effort is desired. Probably this would be close to, or a little below, the 1967 level. Second, as in a single quota for all species, there is the danger that one species might become over-exploited, and another under-exploited. Finally, there is the need to keep the efficiency or fishing power of the vessels under review, to ensure that the permitted number of vessels is in fact exerting the desired effort, and if necessary change the number. To overcome the second problem, it would be necessary to eventually limit, in addition to limiting the total number of vessels in the fishery, the number of vessels which would be allowed to fish in certain areas of the fishery so as to ensure fishing on each species at the optimum level.

Of course, before limitation within areas could become operative, it would be necessary to carry forward detailed analysis to determine the time and areas wherein each of the four species of tunas are most abundant.

In addition to these problems of a scientific nature which need elucidation, there are certain other problems of a political and economic nature which call for attention. Specifically the most important problems would be: (i) to establish a system to determine which countries would be allowed how many vessels, or how much catch and, (ii) the establishment of provisions for the entry of new fishing countries into the fishery.

2.2 The surface fishery for tunas in the Indian Ocean

Available statistical data on the surface fisheries for tuna in the Indian Ocean indicate catches to be of a negligible quantity relative to catches generated by the longline fishery. With the exception of bluefin near Australia, skipjack tuna appear to be the dominant species taken in surface fisheries.

The possibility of increasing the total production of tuna in the Indian Ocean by decreasing the size at first capture through the development of a surface fishery was not considered by the group. However, it is noted that in the Miami report this possibility was considered and that report concluded that for yellowfin tuna this might be a possibility. However, before this could be firmly established for the Indian Ocean, it would be necessary to determine the population parameters needed to employ models of yield per recruitment. It would also be necessary to identify areas where concentrations of smaller tunas occur in fishable quantities.

Figure 12. Main areas of commercial shrimp fishing in the Gulf between Iran and Arabic Peninsula

(Please see remarks "PREPARATION OF THIS PAPER")

3. SHRIMP

The shrimp resources in the Gulf between Iran and the Arabian Peninsula, referred to in this report as "the Gulf", have been the subject of a rapid increase in exploitation during the past ten years. Countries bordering the Gulf have expressed concern about the possible effect on the stocks of the increasing number of boats operating.

This report provides a statement on the state of the shrimp stocks in the Gulf. The data examined were catch and effort figures supplied by the Governments and fishing companies in the Gulf area. Detailed analyses of these data are given in Boerema (in press).

3.1 The fishery

3.1.1 Area

Figure 12 shows the main fishing areas in the Gulf. Four main grounds are recognized: the Hermus Strait on the Iranian side (I); the Iranian coast in the Bushehre-Dayer region (II); the coast of Kuwait and Iraq (III); and a number of isolated areas along the coast of Saudi Arabia, Bahrain and Qatar (IV). Most of the catches are taken within 12 miles of the coast, down to depths of about 15-20 fm; exploratory cruises have undertaken test fishing in waters farther offshore, but significant catches have not been taken. Neither have commercial quantities of shrimp been found during exploratory cruises in the area off the Trucial States.

3.1.2 Species

The dominant species is Penaeus semisulcatus which accounts for more than 90% of the catch. Reports indicate that other species taken probably are Penaeus latisulcatus, Parapenaeus spp., Metapenaeus spp., Solenocera spp., and possibly others.

Observations on the development of the ovaries of P. semisulcatus indicate that the main spawning period is during spring and early summer. Recruitment into the fishery takes place mainly in July and August of each year. The fishing pattern is, therefore, one of high catch rates in the months of July, August, September and October followed by lower catch rates during the following eight months. As the life span in the fishery is probably of the order of one year, each season's fishery is dependent upon one recruit class.

Evidence on the movement of shrimps within the Gulf is not available. However, data on the time of occurrence of peak catches of each size group in the various areas indicate that, once the young shrimps appear in a major fishing area, they remain there throughout the greater part of their life span. The fishery in a particular area, therefore, depends upon the recruitment of young shrimps to that area. However, there may be some mixing of larvae from different stocks; data are not available on this point.

3.1.3 Vessels

The majority of the vessels operating in the Gulf are twin-rigged trawlers ranging from 40 to 85 ft in length.

3.1.4 Development of the fishery

The industrial shrimp fishery commenced in about 1959, both in Iran and Kuwait. In the first years the rate of development was slow. However, from 1963 the industry has developed rapidly, and by the beginning of 1969 there was a total of ten companies actively participating in the shrimp fishery: one based in Iran, one in Iraq, four in Kuwait, two in Saudi Arabia, one in Bahrain, and one in Qatar. The total number of boats involved was 125. In addition, a small number of vessels from nations foreign to the Gulf area have fished there from time to time, usually under contract to one of the national companies. Table 2 shows the growth pattern of the fishing fleet. Information from a number of sources has resulted in different figures for the number of trawlers in the first years of the industry. In these cases the lowest and highest figures are both included in the table.

Table 2 - Number of boats fishing, total landings by these boats, and average catch per boat per year (in '000 lb)

Year	number of boats	total landings	average catch per boat
1959	6 (10)	800	133 (80)
1960	11 (18)	1,500	136 (83)
1961	13 (20)	2,200	169 (110)
1962	15 (18)	1,200	80 (67)
1963	21	4,000	190
1964	33	7,500	227
1965	55	14,800	260
1966	82	20,000	244
1967	110	18,000	164
1968	125	22,000	176

The catch, shown in Table 2 in pounds tail weight, increased rapidly until 1966; in the following two years the catch remained at about the level of the 1966 production despite a substantial increase in the number of boats. As a result, the catch per boat per calendar year fell to a markedly lower level in the years 1967 and 1968. It should be noted that throughout this text, all catch figures are in pounds tail weight. The ratio of tail weight to whole weight is approximately three to five.

It should also be noted that the figures given in this report refer only to the catches of the modern commercial fishery and do not include the quantities caught by the traditional inshore fisheries which are carried out and have some importance in many of the coastal areas. There are indications that these amount to at least a few million pounds of shrimp annually. It has been assumed in the present analysis that this quantity has remained more or less stable over the period under investigation and will not have affected the trend in the landings to any extent.

3.2 State of the stocks

3.2.1 Coastal waters off Iran

As described above, there are two main fishing areas off the Iranian coast: the Bushehre-Dayer area and the Hormuz Strait. The data available refer to a combination of both areas. However, as the major portion of the catch was taken in the Bushehre-Dayer area, the trends shown in the total catch and effort data will represent the shrimp fishery in that area.

Figure 13 gives the catch, number of boats, and catch per boat for the years 1960 to 1968. The catch per calendar year increased until 1965, and thereafter declined. However, the catch of each calendar year comprises the larger animals from one recruit year-class (i.e. the catch of January to June) and the smaller animals from the following recruit year-class (i.e. the catch of July to December). If the annual catch per recruit class is considered, the catch data from the years 1965/66, 1966/67 and 1967/68 fluctuate around a horizontal line. The data indicate that increasing the effort further will not result in an increased catch but will cause the catch per unit of effort to decline below its present value of about 20,000 pounds per boat per month. Figure 14, which gives the data for catch on effort, also indicates that an increase in the effort is not likely to increase the catch. Additional data on the effect that fishing is having on the shrimp population is given by the ratio of the catches taken in the first six months to those taken in the second six months of fishing the

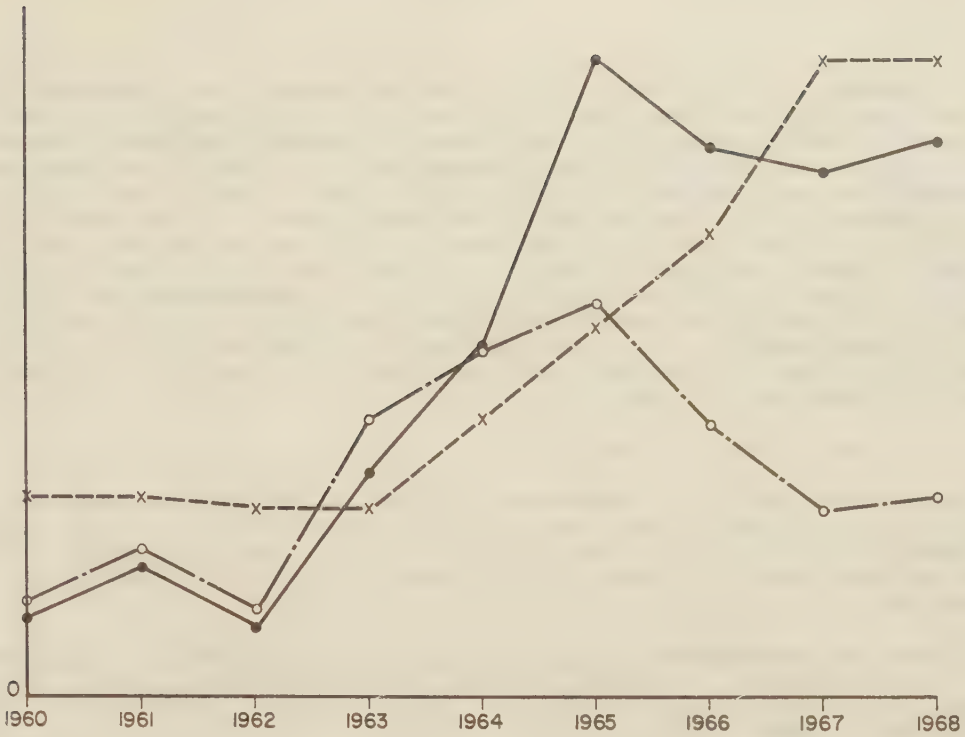

Figure 13. Shrimp fishery off Iran. Number of boats (x---x), total catch (●——●) and catch per boat (o-·-o), per calendar year

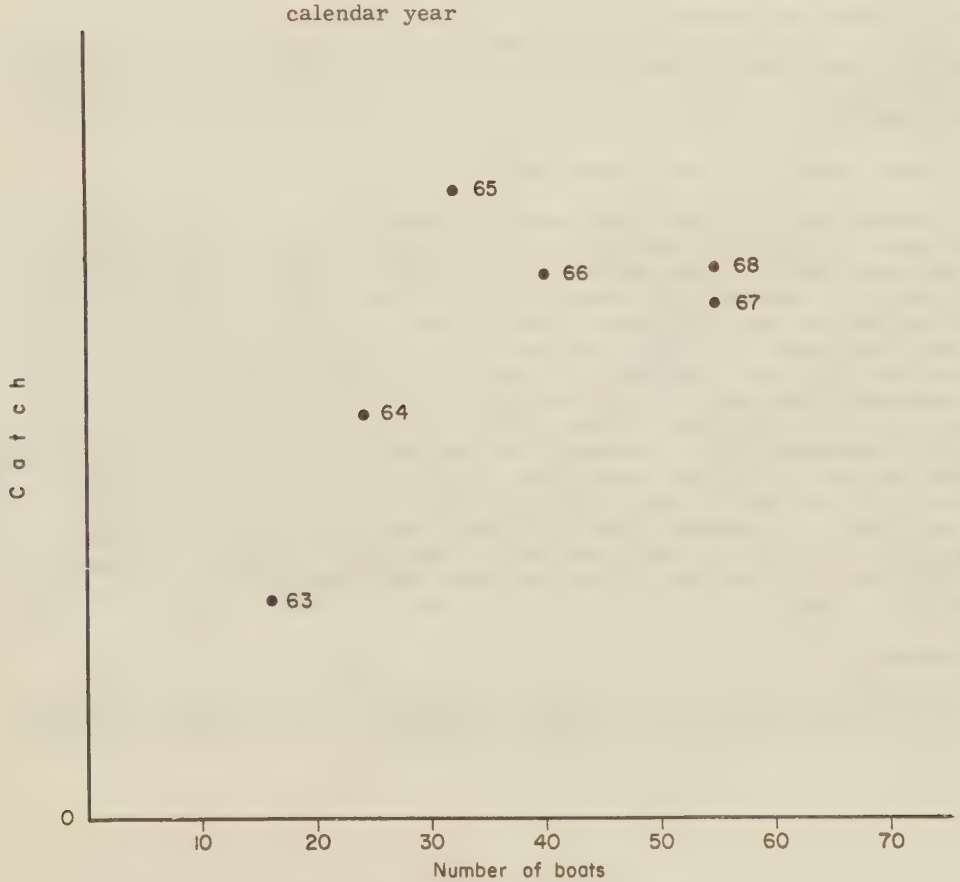

Figure 14. Shrimp catch per boat per year at different levels of fleet size, in the area off the Iranian coast

recruit classes of 1965, 1966 and 1967. Of the 1965 recruit class approximately 50% of the catch was taken during the first six months, i.e. July to December. In the following two recruit classes, when the effort had increased considerably, approximately 85% of the catch was taken during the first six months. In each of the three periods considered, the catch remained at about 9 million pounds. The data indicate that the average maximum yield from the stocks off the Iranian coast is of the order of 9 to 10 million pounds per recruit class (and hence, on the average, per year), with some fluctuations around this average depending upon variations in recruitment. This estimate is made on the assumption that the number of shrimps surviving to maturity is sufficient to maintain an average recruitment level. However, it is quite clear that the fishing mortality is now a high proportion of total mortality, and it is necessary to collect detailed statistical data so that the strength of each year's recruitment class can be measured.

3.2.2 Coastal waters off Kuwait

Shrimp fishing off Kuwait commenced in 1959 but remained at a low level of production for the first few years. However, during the second half of 1965 the catch increased considerably as a result of the entry into the fishery of two new companies. Figure 15 shows the annual catch, the number of boats operating the average catch per boat per calendar year since 1965.

Although the data available for the Kuwait fishery do not provide a clear picture of the state of the fishery, it appears that the fishing mortality is already a large fraction of the total mortality and that the level of maximum yield from this stock may have been reached. The yield appears to be in the order of three to four million pounds per recruit class (and hence, on the average, per year) with substantial fluctuations in recruitment as well as in availability due to environmental factors from year to year.

It should be noted that there is a fishery on a small species of shrimp in the Kuwait area with a total catch of about 500,000 pounds tail weight. This fishery may increase and other small shrimp species resources may be found and exploited. However, it is unlikely that any significant new resources of P. semisulcatus will be located in the Kuwait area.

3.2.3 Coastal waters off Saudi Arabia, Bahrain and Qatar

Figure 16 shows the total catch, the number of boats, and the average catch per boat per calendar year. A number of boats belonging to companies established in other countries have been fishing in this area for part of the year 1968. An attempt has been made to take this into account when determining the effort figure of effective boats. The figures used in the graph of Figure 16 are, therefore, approximate only. Even so they do show that after an initial increase in all three statistics to 1965, the number of boats and the catch continued to rise but the catch per boat-year remained reasonably constant. This stability of catch per unit of effort may have been due to an extension of the fishing grounds in this area. The data indicate that the catch would rise with increasing effort. However, an examination of the data on the relative numbers of the various size groups suggests that the fishery might be approaching a status similar to that off the Iranian coast. If this is so, it is possible that the production could still be increased above the present catch of 9 million pounds, but that the increase is not likely to be more than, say, 2 to 3 million pounds. A more satisfactory evaluation of the size of the stocks in this area will have to wait until more data are available.

3.2.4 Summary

For the fisheries off the coasts of Iran and Kuwait, the data indicate that the

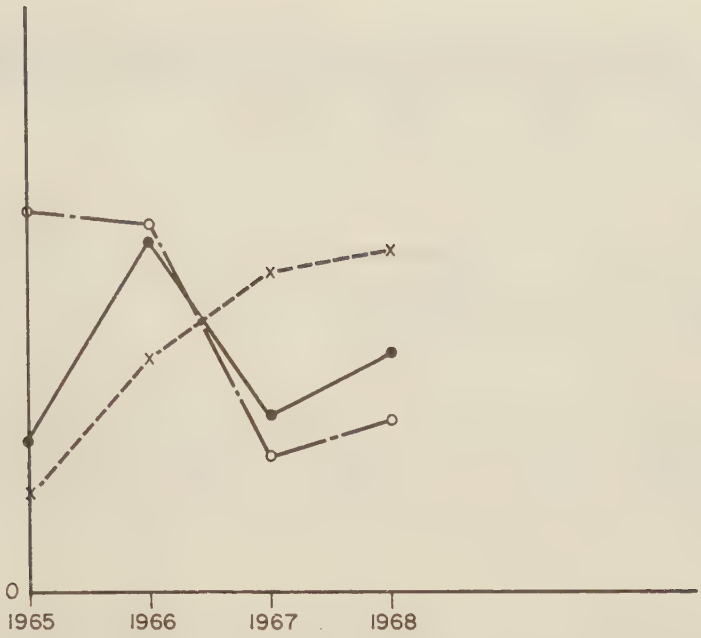

Figure 15. Shrimp fishery off Kuwait. Number of boats(x---x), total catch (●——●) and catch per boat (o—·—o) per calendar year

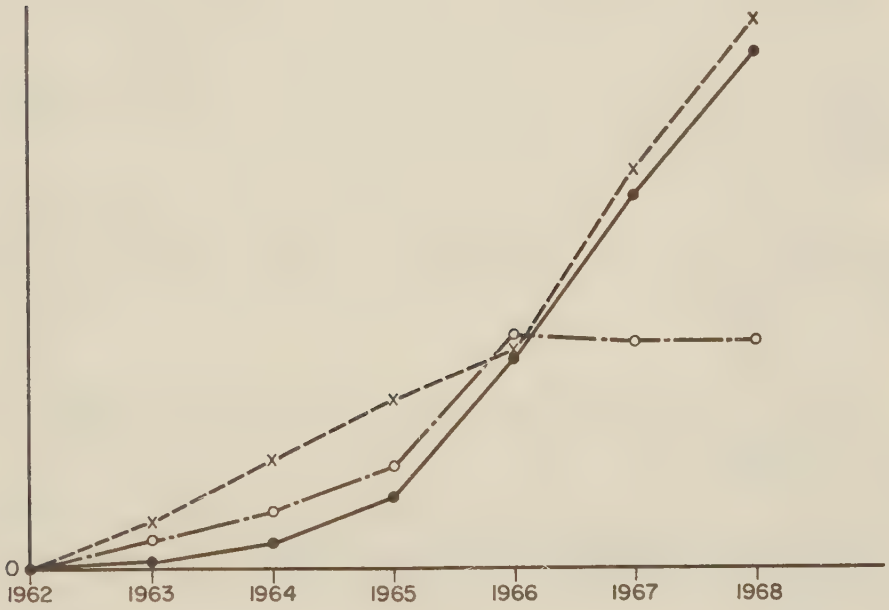

Figure 16. Shrimp fishery off Saudi Arabia (including Bahrain and Qatar). Number of boats (x---x), total catch (●——●) and catch per boat (o—·—o) per calendar year

catches have reached about their maximum yield with an annual production of about 9 to 10 million pounds of tails and 3 to 4 million pounds of tails respectively. Although the possibility of locating new stocks cannot be discounted, it is considered by the study group that the fishery is probably now operating on the major portion of the population.

Increase in the number of boats fishing is unlikely to produce an increase in the total production. In fact, an increase in fishing effort would further decrease the number of shrimps reaching maturity and possibly reduce the spawning potential of the stocks to a point whereby recruitment was adversely affected. Under these conditions, both the total catch and the catch per unit of effort would decrease. Although the data available to date do not indicate a decrease in the recruitment level, the risk of such an event should not be neglected.

The data for the waters off Saudi Arabia, Bahrain and Qatar are too limited to be capable of clear interpretation. The catch could be increased by increasing the effort. However, there are also indications that the state of the stocks is approaching that in the waters off Iran. It is possible, therefore, that the present production of about 9 million pounds tail weight may not be capable of much increase.

3.3 Needs for management

3.3.1 Iran

The data indicated that the average annual production of shrimp off the Iranian coast is unlikely to rise above the present level of 9 to 10 million pounds tail weight. Any increase in the number of boats operating will reduce the catch per boat and thus the profitability of the operation per unit of capital input.

Although the data available do not indicate a decrease in the recruitment level of young shrimp, fishing has caused a reduction in the number of shrimps reaching maturity and the possibility of a reduction in recruitment should not be neglected.

The Working Party considered the possibility of maintaining the fishing effort in the Iranian shrimp fishery at the present level, and noted that an authority exists within Iran which provides a mechanism for boat limitation.

In recent years the fishery has been closed during the months of May and June. This action may have assisted in reducing the fishing mortality slightly thus increasing the breeding potential of the stock, and it may limit the capture of some shrimp of a small size. However, there are insufficient data available to make any further judgement on this point.

3.3.2 Kuwait

The data available indicate that the state of the stock is similar to that off the Iranian coast. Increasing the fishing effort is unlikely to result in catches much above the present level of between 3 and 4 million pounds tail weight, and might well lead to reduced catches. Consideration might, therefore, be given to the desirability of limiting the number of shrimp boats fishing off the Kuwait coast to that level presently employed in the area. This would tend to stabilize the catch per unit effort and maintain the breeding population. However, it should be noted that there is no specific evidence available at the present time on the size of the breeding stock required to maintain the recruitment level.

3.3.3 Saudi Arabia, Bahrain and Qatar

The waters off these three countries have been considered as one area. The data indicate that the catch could be increased by increasing the fishing effort. However,

the maximum annual yield is probably not very much greater than the present catch of about 9 million pounds tail weight. If the effort is limited in other areas of the Gulf, any additional boats in the area would, no doubt, seek to fish on the western side of the Gulf resulting in higher catches to a point where the average maximum yield is reached. The stocks in this area also might become fully exploited. It might be desirable, therefore, to consider ways and means of ensuring that action is taken at the appropriate time.

3.3.4 General comments on licence limitation as a required measure

Licence limitation as a means of managing a fishery is not without its attendent problems. Those who are fortunate enough to obtain a concession for a particular fishery may tend to become less efficient in their operations or to be less keen on improvements in their efficiency. This is more likely to occur if the price structure of the commodity changes such that the profitability of the operation is increased considerably. Also, if all available boats are allocated to concession areas, there is little pressure to search for new areas outside those already being fished. In the case of the Gulf, this does not seem to be likely to occur; new shrimp trawlers are being built by at least one of the companies operating in these waters and the pressure of numbers of trawlers available will necessitate the continuance of exploratory fishing between Qatar and the Hormuz Strait, and outside the Strait.

If a system of license limitation is introduced in one area of the Gulf and other areas remain open, it is likely that the excess fishing capacity, which might have been spread over the shrimp grounds of the Gulf, will be concentrated on the open areas probably resulting in a lower catch per unit effort, in the latter areas.

3.3.5 Change in size at first capture

At the present time, the shrimp start to enter the fishery at a tail weight of approximately 60 per pound or even smaller, as is apparent from the landing data. Reportedly, substantial quantities of shrimp of more than 70 per pound may be discarded at sea at the beginning of the recruitment season, which would mean that the actual size at which the shrimp becomes liable to capture is rather lower than that indicated by the size composition of the landings. Under conditions of high fishing mortality, it is possible that the total catch could be increased by allowing the small shrimp to grow to a size averaging, say, 40 tails per pound weight.

The average weight of a shrimp smaller than 40 tails per pound in the present landings is about 9.1 gr, and the average weight of a shrimp larger than 40 per pound in the present catches is about 15.8 gr (data based on catches on the Iranian coast. If the shrimp smaller than 40 per pound would not have been caught, as a result of special protection measures, a number of these shrimp would have died of natural causes before entering the fishery at a size of 40 per pound. Of the survivors, a fraction equal to the exploitation rate would be caught at an average weight of 15.8 gr, (at the present level of fishing effort). If 100 small shrimp with average weight 9.1 gr, are released, then the total catch (in weight) will increase if the number caught later, at an average weight of 15.8 gr, is greater than $\frac{100 \times 9.1}{15.8} = 58$. Taking into account some natural mortality before the shrimp has reached the new recruitment size of 40 per lb, the present exploitation rate must be greater than, roughly, 60%, for the protection of these small shrimp to result in higher catches. Making the same calculation for protection of small shrimp up to the size of 50 per lb, gives about the same figure. However, any protection of those young shrimp which are at present caught and discarded and often die in this procedure, will result in higher catches.

It is probable that protection of the small shrimp can be accomplished more readily by stopping fishing in months of peak recruitment, e.g. the month of July for the Iranian coast, and August for the areas off Kuwait and Saudi Arabia, rather than by regulation of a mesh size. The data available are, however, not sufficient to permit the determination of the exploitation rate and the numbers of young shrimp which are discarded, and advice on the expected effect of such measures on the total catch is, therefore, not possible.

3.3.6 Need for additional data

The analyses to date have been undertaken on gross catch and effort data, and rather more detailed data from several companies in relation to the more recent years. Some casual observations on aspects of the biology of the animal have also been taken into account. Even the gross data are, in some cases, rough approximations.

The shrimp fishery in the Gulf is now heavily exploited, and the study group is of the opinion that detailed catch and effort data are essential if IOFC requires a continuing appraisal of the status of the shrimp stocks. In relation to the collection of data, it is recommended that the following are required as a minimum:

(i) Collection of catch and effort data for the total fishery giving the catch per month in size grade categories, and the effort in terms of the number of days fished by each boat in each month. These data are required for each fishing ground in units of area as small as practicable.

(ii) Examination of the species composition of the catches of both the modern commercial fishery and the artisanal fishery.

(iii) Collection of biological information, with special reference to a study of the stock identities and the time and area of spawning.

The present analyses have been based on incomplete data; in particular, detailed information for the earlier years for some areas was not available. The provision of additional catch and effort data for past years by the companies concerned would increase considerably the accuracy of the conclusions reached on the state of the stocks.

3.3.7 Alternative possibilities of management measures

(i) No action

If no management action is taken, all available information indicates that the fleets will continue to expand, possibly in all areas. The result of this will probably be no increase in the total catch in the areas off Iran and Kuwait, and there may even be a decrease. The catches on the Arabian side of the Gulf will probably increase somewhat further. Certainly in Kuwait and Iran, and probably also in Saudi Arabia, the catches per boat will decrease.

(ii) Stabilization of the fleet in each area at its present level

This will probably maintain the total catches and the catches per boat at their present level, except for fluctuations due to environmental factors.

(iii) Catch quota

An overall catch quota for each area at about the level of the average catch in the last few years would decrease the possibility of a future decline in catches due to the effect of fishing on the spawning stock. It will by itself not prevent a further expansion of the fleet with the corresponding decrease in the catch per

boat and shortening of the fishing season. This would only be obtained if the quota were in some way allocated to the individual companies. A successful catch quota system, which takes account of natural fluctuations in recruitment, would depend on the possibility of obtaining early and fairly accurate estimates of the magnitude of the recruiting year-class of young shrimp, which does not seem feasible for the moment, and on prompt and accurate reporting of the catches.

(iv) Regulation of the size at first capture

As explained above, this might be most easily done by closing the fishery in the period of the peak recruitment of small shrimp. Insufficient data are available to determine whether this would lead to an increase in the weight of the total catch at the present rate of fishing. It would certainly increase to some extent the amount of large shrimp caught and the numbers surviving until spawning age. It cannot yet be determined whether the advantages of the latter facts will outweigh the disadvantage of a possible loss in total weight of the catch.

(v) Small shrimp species

The foregoing discussion has been concerned primarily with the fishery for P. semisulcatus. It has not been possible for the group to determine to what extent the fishery for small shrimp species, as mentioned in section 3.2 above, can be expanded.

4. RECOMMENDATIONS

The Working Party makes the following recommendations to facilitate the scientific study and rational exploitation of tuna and shrimp in the areas of their concern.

4.1 Tuna

(i) Examination of currently available catch statistical data to estimate the average maximum sustainable yield of yellowfin, bigeye, albacore and southern bluefin tunas in the Indian Ocean and current levels of average sustainable yield.

(ii) The collection of more extensive and comprehensive statistics on total catch and effort generated to make these catches in order to better refine estimates of 4.1 (i) above, and to monitor changes in abundance.

(iii)The determination of mortality and growth rates, and the distribution of size classes of longline caught fish in order to estimate possible affects of altering the size composition of the catch and hence total potential yield. Emphasis should be place on southern bluefin tuna.

(iv) A detailed examination of the distribution of species abundance by strata of time and area in order to facilitate the implementation of various management strategies as suggested above.

(v) The establishment of a scientific body to carry forward recommendations (i) - (iii) above since it will be impossible for the present Working Party to accomplish this.

(vi) Urgent consideration of the desirability of holding constant or reducing fishing mortality on tunas captured by longline gear in the Indian Ocean, and taking action if considered appropriate.

(vii)Examination of possible mechanisms for managing the entire population of southern bluefin tuna as a single stock, since as noted in 2.1.1 (d) it appears to be a single subpopulation inhabiting the waters of the Atlantic, Pacific and Indian Oceans.

4.2 Shrimp

(i) Consideration of the results of the alternative management measures given in section 3.3.7, especially in relation to the control of fishing effort and the taking of action if considered appropriate.

(ii) The collection of more extensive and comprehensive statistics on total catch and effort together with certain biological data as set out in section 3.3.6 of this report.

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